Lasers in Surgery and Medicine 19:480–486 (1996)

Nd:YAG Laser Transurethral Evaporation of the Prostate (TUEP) for Urinary Retention

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Background and Objective: **Little information is available regarding the effectiveness of laser prostatectomy in patients with urinary retention from benign prostatic hyperplasia since there is no paper specifically dealing with laser prostatectomy in patients in urinary retention.**

Study Design/Materials and Methods: **Twenty two unselected consecutive patients presenting with urinary retention due to benign prostatic hypertrophy underwent transurethral evaporation of the prostate (TUEP) using a neodymium:YAG laser and total internally reflecting side-firing free beam quartz fiber. All patients failed at least one voiding trial and averaged >30 days of urinary catheter drainage preoperatively. A contact evaporation technique was used to evaporate a "TURP-like" channel in the prostatic fossa by means of a series of parallel evaporation troughs.**

Results: **Eighteen of 22 patients completed 6 months of follow up. Two patients were lost to follow up and two failed TUEP. The average AUA score dropped from 26 to 9 at 1 month and to 3.4 by 6 months postoperatively. All patients who successfully underwent TUEP were urinating spontaneously by 10 days. Average time to catheter removal was 3.5 days. Maximal uroflow was 15.7 ml/sec at 1 month and 20.3 ml/sec by 6 months. Postvoid residual preoperatively averaged 784 ml and decreased to 76 ml by 1 month. Pre- and postoperative hematocrit and serum sodium values did not vary by more than 5%.**

Conclusion: **From this preliminary series we conclude that aggressive evaporation of prostatic tissue is feasible endoscopically and provides a reliable method of near bloodless removal of tissue.** © 1996 Wiley-Liss, Inc.

Key words: Nd:YAG laser, prostate, urinary retention

INTRODUCTION

Urinary retention due to bladder outlet obstruction from benign prostatic hyperplasia (BPH) is the most severe urodynamic manifestation of this disease. Little information is available regarding the effectiveness of laser prostatectomy in patients in urinary retention from benign prostatic hyperplasia since there is no paper specifically dealing with laser prostatectomy in patients in urinary retention. What little data is available suggests that the visual laser ablation (VLAP) technique as described by Johnson et al. [1,2] and

Accepted for publication June 20, 1995.

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Costello et al. [3,4] and may only be marginally effective in rapidly relieving the high grade bladder outlet obstruction. Norris et al. [5] reported postoperative urinary retention in 6 of 9 patients in retention preoperatively. Marks [6] reported satisfactory results in 4 of 5 highly selected patients with BPH in urinary retention all with glands that were less than 40 grams in size. The one patient failing treatment had a prominent middle lobe and required reoperation. Daughtry and Rodan [7] in their series of 66 laser prostatectomies reported good results in 7 patients with BPH presenting in urinary retention wherein the VLAP technique was used, but the fibers used were internal reflector fibers that did not use metal reflectors and produced a spot with much higher power density than the metal reflector fibers used by Johnson et al. [1,2], Costello et al. [3,4], and Norris et al. [5]. In this sense Daughtry and Rodan may have effected a greater degree of tissue evaporation. In this communication we report the results of a form of laser prostatectomy that achieves evaporation rather than coagulation of the adenomatous tissue, a technique we call transurethral evaporation of the prostate (TUEP) in 21 consecutive unselected patients presenting in urinary retention from BPH to the V.A. Medical Center.

MATERIALS AND METHODS

Equipment and Surgical Technique

A totally internal reflecting (TIR) quartz fiber was used which has a 600 micron internal reflector fiber covered by a glass cap that reflects the Nd:YAG beam at 80° to the fiber axis (Ultraline®, ACMI Stanford and LaserSonics, Milpitas, CA). This fiber is capable of transmitting a high power density beam (spot size of 700 mm^3 and divergence of 15–20°, giving a power density at 60–80 watts of 15,600 to 21, 231 w/Cm^2) (Fig. 1). The usual fibers used for VLAP have a wider angle of divergence and thus the power density delivered is low. Even though this low power density is sufficient for deep thermal coagulation of prostate (which later sloughs over few weeks), the power density is insufficient to achieve immediate tissue evaporation which is the key point of our technique. Further most other VLAP fibers, if brought in contact with tissue, results in adherence or trapping of tissue on the fiber tip; excessive heating of fiber; and finally melting or distortion of reflecting mechanism. Currently many fibers are available on the market which can deliver high wattage laser energy, have narrow angle of divergence (by a internally reflecting mechanism), are covered by a glass cladding (thus can be used in contact mode), and are capable of withstanding heating of tip. Any of these fibers can be used for evaporation. A 100 Watt neodymium: YAG (Nd:YAG) laser was used in all patients. Power output used was 60–80 W. The technique of tissue evaporation was as described in previous work characterizing the laser/tissue interaction seen with contact evaporation of soft tissue using TIR fibers [8]. Briefly, the fiber tip is placed in contact with tissue then axially rotated back and forth in a 30–45° arc while simultaneously withdrawing the cystoscope to create a series of evaporation troughs that extend from the bladder neck to the verumontanum. Four sentinel troughs are created to establish the depth of evaporation visually. The first two are at 4 and 8 o'clock on the bladder neck followed by complete contact evaporation of any bladder neck tissue or median lobe between these troughs. Next, two additional sentinel troughs are created at the 2 and 10 o'clock positions next to the anterior curve of each lateral lobe, followed by evaporation of all lateral lobe tissue between the 2 and 4 o'clock troughs and the 8 and 10 o'clock troughs. Usually no evaporation of tissue between the 2 and 10 o'clock troughs anteriorly is needed. At the apex any all tissue which protrudes into the visual field is evaporated so that a completely clear open view of the bladder lumen is obtained with the scope positioned at the verumontanum. Bleeding points are few, and are easily coagulated by noncontact coagulation using 5–10 sec pulses of the laser and placing the fiber 1–2 mm away from the point of bleeding.

Patients

Twenty-two patients were referred to the urology division either through the emergency room or by way of consultations from ward physicians. Average age was 72 (53–89) years and mean gland volume was 47.5 (16–103) ml as measured by transrectal ultrasonography. All had failed at least one voiding trial after the initial episode of urinary retention. The mean duration of retention was 18 (8–35) days and all were managed with indwelling catheter. Eight of the patients had active neurological or psychiatric disorders. Two were diabetic. The most prevalent comorbid conditions were hypertension and coronary heart disease (12 and 9 patients respectively) Preoperative evaluation consisted of AUA

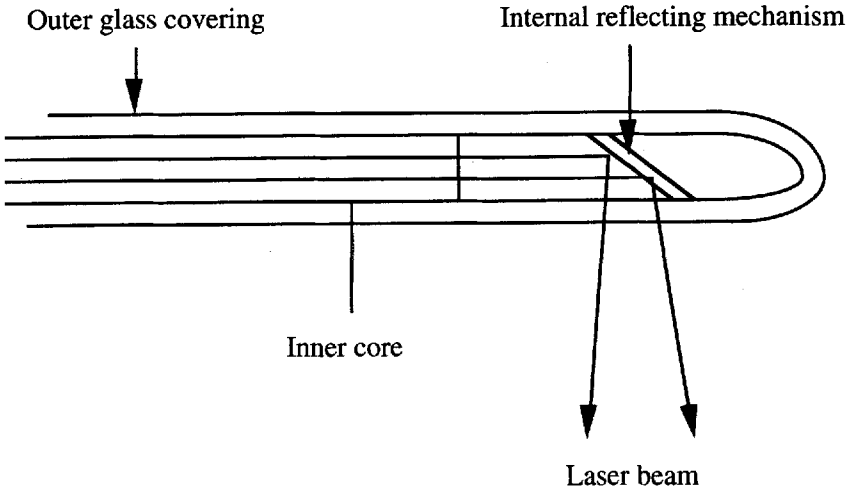

Fig. 1. Mechanism and construction of TIR fiber.

symptom score (Table 1), quality of life assessment (QOL; Table 1), PSA rectal exam, and transrectal ultrasound with biopsy if there was any suspicion of prostate cancer (nodule on rectal exam or PSA >4 mg/dl on two determinations). Patients were asked to relate the AUA score at the time of going into retention. Residual urine at the time of presentation was obtained from the hospital record when recorded by the treating physician. This was available in 12 patients, with the average volume being 784 ml.

Surgery was done using either general or regional anesthesia. A 20 Fr. three way Foley catheter was placed following completion of the surgery, and bladder irrigation was used to maintain the effluent crystal clear and discontinued within 16 h of surgery. Postoperative hematocrit values were obtained 24–36 h following surgery. Serum electrolytes postoperatively were obtained in the recovery room. No medications other then perioperative antibiotics and preoperative medications used to manage preexisting comorbid conditions were used postoperatively. Postoperative follow up visits occurred within 1 week of discharge, within 30–40 days of discharge, at 3 and 6 months, and 1 year. AUA symptom scores and uroflow rates were obtained at the 1, 3, 6, and 12 month visits. Twenty patients had 6 months complete follow-up, and 5 patients completed the 12 month follow-up. One patient had failed a previous attempt at laser prostatectomy done using the VLAP technique and remained in urinary retention for 8 weeks prior to the TUEP. Two other patients had recurrence of BPH 13 and 23 years following a suprapubic prostatectomy and TURP, respectively.

RESULTS

The urodynamic results are summarized in Table 2. There were no perioperative deaths, cardiovascular complications, episodes of clot retention, reoperations for bleeding, blood transfusions, or instances where the postoperative serum sodium decreased to below 132 meq/L. Eighteen patients completed the 6 month follow-up flow rate, two lost to follow-up because they moved out of state. Two patients required TURP 3 weeks following TUEP for persistent obstructive voiding. In both instances there was significant residual tissue left at the apex of the prostate resulting from an insufficiently aggressive evaporation. No patient manifested any clinical evidence of a bladder neck contracture, or experienced significant deterioration in the urinary flow rate throughout the follow-up period. All procedures were completed without the need of electrocautery. Of the 18 patients successfully treated and followed-up for 6 months, the mean time to catheter removal was 3.5 days with only one patient requiring catheterization for more than 7 days. The AUA symptom score by 4 weeks postoperatively decreased from a mean of 26 to 9 (71% decrease) with the quality of life score dropping from 5.3 to 2.2 (58% decrease). By 6 months the mean symptom score was 3.4 and the mean QLS score was 0.7. Over the 6 month follow-up period, the mean maximal flow rate increased from 15.7 ml/sec at 1 month to 20.3

TABLE 1. AUA Score Questionnaire

	AUA Score					
A. Urinary Symptoms (Symptom Score Criteria)	Not at all	Less than 1 time in 5	Less than half the time	About half the time	More than half the time	Almost always
1. Incomplete emptying Over the past month, how often have you had a sensation of not emptying your bladder completely after you finished urinating?	0	1	2	3	4	5
2. Frequency Over the past month, how often have you had to urinate again less than 2 hours after you finished urinating?	0	1	2	3	4	5
3. Intermittency Over the past month, how often have you found you stopped and started again several times when you urinate?	0	1	2	3	4	5
4. Urgency Over the past month, how often have you found it difficult to postpone urination?	0	1	2	3	4	5
5. Weak stream Over the past month, how often have you had a weak urinary stream?	0	1	2	3	4	5
6. Straining Over the past month, how often have you had to push or strain to begin urination?	0	1	2	3	4	5
	None	1 time	2 times	3 times	4 times	5 or more times
7. Nocturia Over the past month, how many times did you most typically get up to urinate from the time you went to bed at night until the time you got up in the morning?	0	1	2	3	4	5
AUA Symptom Score = sum of questions A1 to A7 =						

ml/sec at 6 months. Five patients have been followed for at least 12 months. This subgroup had a mean maximum flow rate of 15.8 ml/sec at 1 month and 22.9 ml/sec at 12 months postoperatively. The maximal flow rates were higher at 6 months than at 1 month in 15 of 18 (83%) patients who had their maximal flow rate measured at 6 months.

DISCUSSION

Of the alternative strategies for treating BPH, none are able to relieve bladder outlet obstruction as quickly and reliably as a properly performed TURP. The immediate removal of the obstructing tissue and establishment of a channel is the key to the effectiveness of the surgery. Conventional TURP does have a significant complication rate due to bleeding [9], and it is the complication rate of the procedure that has provided a significant stimulus for development of alternative forms of surgery for BPH. Of the alternative techniques, laser prostatectomy is the most widely used, and seems to be the most effective. Virtually all reported series make use of high power Nd:YAG lasers whose energy can be transmitted efficiently through quartz glass fibers. The most commonly reported technique is the VLAP technique [1–5], designed to coagulate prostate tissue. The procedure is rapid, causes minimal to no bleeding and can be performed using general, regional, or local anesthesia [10] with sedation, relying principally on the delayed liquefaction of the coagulated tissue to effect removal of the obstructing adenoma. Little or no tissue is actually removed during surgery, consequently no channel is created immediately. Although the VLAP technique is effective for patients not in urinary re-

TABLE 1. AUA Score Questionnaire (continued)

B. Quality of Life due to Urinary Problems*

	none	only a little	some	a lot			
1. Over the past month, how much physical discomfort did any urinary problems cause you?	0	1	2	3			
	none	only a little	some	a lot			
2. Over the past month, how much did you worry about your health because of any urinary problems?	0	1	2	3			
	not at all bothersome	bothers me a little	bothers me some	bothers me a lot			
3. Overall, how bothersome has any trouble with urination been during the past month?	0	1	2	3			
	none of the time	a little of the time	some of the time	most of the time	all of the time		
4. Over the past month, how much of the time has any urinary problem kept you from doing the kinds of things you would usually do?	0	1	2	3	4		
	Delighted	Pleased	Mostly satisfied	Mixed-about equally satisfied and unsatisfied	Mostly dissatisfied	Unhappy	Terrible
5. If you were to spend the rest of your life with your urinary condition just the way it is now, how would you feel about that?	0	1	2	3	4	5	6

*Quality of Life questions are scored individually. Adopted from McConnell et al. (1994) [11]

tention at presentation, the available literature does not give a clear indication of how effective VLAP is in treating urinary retention due to BPH. It has been reported that the most significant side effect of VLAP is a period of prolonged obstructive symptoms in as much as one third of patients not in urinary retention preoperatively [10].

Our studies of the laser/tissue interaction induced by the TIR fiber indicate that efficient tissue evaporation can be achieved by contact evaporation [8]. The TUEP technique exploits this finding to effect more extensive tissue removal at surgery [8]. The results presented here indicate that TUEP is effective in patients presenting with urinary retention. The fact that we have not observed significant deterioration in the maximal urinary flow rate over a 6 month period of time suggests that bladder neck contracture will likely not be a significant problem. The series of pa-

TABLE 2. Results of TUEP in 22 Patients in Urinary Retention Preoperatively*

	Preop n = 22	1 mo n = 18	3 mo n = 18	6 mo n = 18
AUA	26	9	6	3.4
QLS	5.3	2.2	1.5	0.7
Qmax	0	15.7	18	20.3
Qav	0	7.5	9.4	10.5
PVR	784	76	64	5.4

*AUA = American Urological Association symptom score. QLS = Quality of life score. Qmax = maximal flow rate. Qav = average flow rate. PVR = postvoid residual measured in ml. Two patients lost to follow up, 2 patients failed TUEP and required TURP. Failures due to insufficient evaporation of apical tissue.

tients we present here is not large, and a direct comparison with VLAP cannot be made, but we believe that a major advantage of the TUEP technique is the fact that at the conclusion of the procedure the surgeon has an excellent sense for the adequacy of tissue removal, since the endpoint is a TURP-like channel.

From the standpoint of blood loss, in vitro studies [8] indicated that underlying each evaporation trough a zone of 3–4 mm of coagulated tissue was formed, so that one could expect vessels of this diameter or smaller to be adequately coagulated. The insignificant changes in both the pre- and postoperative hematocrit have confirmed this prediction. In addition, the durability of the TIR fiber design is clearly much greater than that of metal reflector fibers since the TIR fiber can withstand prolonged contact with tissue (average fiber tip durability is 100,000 J). The power density of the laser spot is such that previously coagulated and charred tissue evaporates well so that one can continue to enlarge the width of the channel until one reaches the capsule or the channel width is so large that firm contact with the tissue can no longer be maintained.

The TUEP procedure initially takes approximately 25% longer than a comparable TURP. With practice, one can complete evaporation on a 20–30 gram gland in 50 min. We have found that it takes between 2200–2900 J/gram prostate. A reasonable average estimate would be 2500 J/gram of prostate. Assuming a power output of the laser of 60 Watts, one can estimate the time it will take to complete evaporation by simply multiplying the prostate weight by 2500 to estimate the total number of Joules that will be needed to create an adequate channel, then dividing by 3600 to estimate the number of minutes the laser has to be on at the 60W setting to deliver that total number of Joules, then multiply that quotient by 3. For a 30 gram gland, approximately 75,000J of energy will be needed which means that 20.8 min of laser-on time will be needed to deliver that amount of energy, and therefore a total procedure time of approximately 63 min will be required. A continuous flow cystoscope needs to be used because bubbles created during tissue evaporation have to be washed away as quickly as they are formed. There is no cystoscope design on the market that is specifically designed for this type of laser prostatectomy. It is hoped that with increased fiber durability, decreases in fiber price, and availability of endoscopes specifically designed for TUEP, the cost of laser prostatectomy and the time of surgery will decrease significantly. The excellent hemostasis both intraoperatively and postoperatively suggests that TUEP could be used for performing endoscopic prostatectomies on an outpatient basis.

In conclusion, our preliminary experience with TUEP in patients with urinary retention has been very favorable primarily because TUEP recapitulates the tissue removal of the TURP while providing a degree of hemostasis comparable to the VLAP technique. Since the endpoint of the evaporation is to create and open fossa that smoothly funnels down to the apex as viewed from the verumontanum, there is little or no ambiguity as to the adequacy of the laser treatment. We feel confident that TUEP is a reliable method of performing a laser prostatectomy in the most severely affected patients with BPH. With the exception of operating time the TUEP technique of laser prostatectomy compares favorably with TURP. The hemostatic properties of TUEP are excellent with the added assurance that because of the tissue removal by evaporation rapid and reliable relief of urinary retention can be achieved in the vast majority of such patients.

REFERENCES

1. Johnson DE, Levinson KA, Greskovich FJ, Cromeens DM, Ro JY, Costello AJ, Wishnow KI. Transurethral laser prostatectomy using a right-angle laser delivery system. Lasers Urol Laparosc Gen Surg 1991; 1421:36.
2. Johnson DE, Price RE, Cromeens DM. Pathologic changes occurring in the prostate following transurethral laser prostatectomy. Lasers Surg Med. 1992; 12:254–263.
3. Costello AJ, Bowsher WG, Bolton DM, Braslis KG, Burt J. Laser ablation of the prostate in patients with benign prostatic hypertrophy. Br J Urol 1992; 69:603–608.
4. Costello AJ, Schaffer BS. Laser ablation of benign pros-

tatic hyperplasia (BPH) two and a half year experience with right angle delivery systems. J Urol 1993; 149: 214A.
5. Norris JP, Norris DM, Lee RD, Rubenstein MA. Visual laser ablation of the prostate: Clinical experience in 108 patients. J Urol 1993; 150:1612–1614.
6. Marks LS. Serial endoscopy following visual laser ablation of prostate (VLAP). Urol 1993; 42(1):66–71.
7. Daughtry JD, Rodan BA. Transurethral laser prostatectomy: a comparison of contact tip mode and lateral firing free beam mode. J Clin Laser Med Surg 1993; 11(1):21–28.
8. Fournier GR, Narayan P. Factors affecting the size and configuration of neodymium:YAG (Nd:YAG) laser lesions in the prostate. Lasers Surg Med 1994; 14:314–322.
9. Mebust WK, Holtgrewe HL, Cockett ATK, Peters PC. Transurethral prostatectomy: immediate and postoperative complications. A cooperative study of 13 participating institutions in evaluating 3,885 patients. J Urol 1989; 141:243–247.
10. Leach GE, Sirls L, Ganabathi K, Roskamp D, Dmochowski R. Outpatient visual laser prostatectomy under local anesthesia. Urology 1994; 43(2):149–153.
11. McConnell J, Barry M, Bruskewitz R, Bueschen A, Denton S, Holtgrewe H, Lange J, McClennan B, Mebust W, Reilly N, Roberts R, Sacks S, Wasson J. Benign prostatic hyperplasia: Diagnosis and treatment (Clinical practice guideline No. AHCPR No. 94-0582). U.S. Department of Health and Human Services, 1994.